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Biogeosciences Discussions

Interactive comment on "Factors controlling the temporal variability of mass and trace metal downward flux at 1000 m depth at the DYFAMED site (Northwestern Mediterranean Sea)" *by* L.-E. Heimbürger et al.

L.-E. Heimbürger et al.

heimburger@obs.lmtg-mip.fr

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Responses to Reviewer M. Rutgers van der Loeff

General comments: This is a very straightforward short paper describing mass and trace metal fluxes collected at DYFAMED in the period 2003-2005. The authors show that trace metal fluxes are very well correlated with each other and with total mass flux. Better than would be expected if these fluxes were controlled by their different supply rates to the ocean surface. The authors conclude that at this site all fluxes are

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controlled by the seasonal variability of biogenic carbon production and flux. This is an interesting contribution to the discussion on the role of ballast materials and organic carbon production in the vertical flux. As the authors explain their observations by a controlling role of the organic flux, it is surprising that the paper does not give data and correlations with the fluxes of POC, CaCO3 and biogenic silica, which are most probably also available for these periods. We do not even know the composition of the mass flux: Is this primarily organic or does the ballast material constitute a significant amount?

We did not provide POC data for two reasons: - On the one hand, we tried to keep the manuscript in its short, straightforward form. - On the other hand, we think that introducing POC data would not make our purpose clearer. It is foreseeable that the covariance between trace metals (TMs) and POC would be much less good than that between TMs and mass flux. Indeed, two of us have already published temporal variations of Al/mass flux ratios at 200m depth, from sediment trap time-series at the DYFAMED site (Migon et al., 2002). These ratios exhibit maximum values in January-February (period of winter mixing), because the mineral material supplied by atmospheric inputs has accumulated during the period of minimal transfer (period of oligotrophy/stratification), and there is not much biogenic material. On the contrary, in March-May (period of maximum biological production), Al/mass flux ratios are significantly lower, because the transfer is now high and driven by biological productivity and atmospheric inputs have not accumulated, thus TM fluxes are lower. As a result, the percentage of biogenic material is high. Therefore, comparison of POC and TM flux seasonal patterns exhibit differences along seasons. This, however, does not contradict our findings: Apart from biogenic silica and carbonates (we do not have the data), mass fluxes gather both biogenic and mineral material, and the covariance between mass and TMs fluxes suggests that every time particles are transferred from surface to depth, TMs are found in sediment trap material. Since, in addition, there is a correlation between all TMs in sediment trap samples (in spite of different emission temporal patterns: when Saharan dust events occur, loads of Al or Fe enter sea surface, but loads of Pb or Zn do not; when anthropogenic atmospheric events occur, loads of Pb or Zn enter sea surface, but loads of Al or Fe do not), one can infer that the occurrence of Saharan dust events (or that of anthropogenic events) does not determine downward fluxes. On the opposite, biogenic particles drive fluxes of mineral material. This is in agreement with the respective size of atmospheric and biogenic particles, and with Stokesian calculations (Stokes, 1901). Ultimately, this does not contradict mineral ballasting: even if mineral material cannot sink without packaging with biogenic material, its density increases the sinking rate of biogenic particles.

2. The authors exclude in their analysis (Fig.2, data file) a high-current period of the sediment trap record. On page 2554 they argue that high currents may affect trap fluxes both qualitatively and quantitatively, but in the figure legend they mention that they will calibrate the fluxes with 230Th. Such corrections will not change the TM/mass flux ratios. If the excluded periods have a poorer correlation between TM and mass flux (which is not stated), this would point at a qualitative bias of trapping, which would be an important finding. It is correct that the high-flux period is highlighted, but I think the data should be shown nevertheless. We agree, years 2005 and 2006 are now included in the data set. One can observe that our results do not significantly change. This suggests the qualitative bias due to non rectilinear position of the traps is negligible.

Page 2552 line 5-11. The information derived from the sedimentary record is not fundamentally different from the information derived from sediment traps: it is a question of time scales. Yes, we agree. The sentence now reads: "...sinking particles in sedimentary records or sediment traps presumably...".

Page 2555 line 10. The website does not appear to be a permanent one.

Answer: It is a permanent one. However, data can be found now at the following (permanent) address: http://www.obs-vlfr.fr/∼migon/Files/Flux%201000m.pdf

Page 2558 line13-16. The function of this sentence at this position is not clear. Indeed, we removed this sentence at this position and put it in the conclusions.

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Page 2559 line 5. The paper shows indeed that the actual ïňĆuxes at a given time, the TM dynamics, depend on the climatic/meteorological conditions that control the organic ïňĆux. But the the average ïňĆux over longer periods and the accumulated ïňĆux in the sediments is ultimately controlled by the inorganic inputs to the surface water. There is a consensus on the fact that TM supply to oceans is mainly due to atmospheric deposition. But, if we keep in mind that the residence time of surface (0-200m) Ligurian waters is approximately 100 days (Migon et al., 1991), the removal of TMs from the water column is ultimately controlled by climatic/meteorological conditions, because during this residence time, only biogenic carbon production is likely to drive TM transfer to depths (apart from the winter episode of convection). In other words, if during this residence time TMs are not transferred to sediment, they exit the Ligurian Sea, and, therefore, the Ligurian downward flux of TMs is reduced. For example, if a decade of heat leads to low convection and low productivity, every year, during the residence time of Ligurian waters, the transfer of TMs will be low, and this decrease of TM transfer should be recorded in sediment. Any change in climatic/meteorological factors presumably impacts TM fluxes beyond the yearly scale. In other words, physical parameters actually control TM dynamics (i.e., their removal rate), even at longer time scales. This is now briefly addressed in the manuscript.

Legend Fig.2 mentions correlation coefïňĄcients between TM and mass ïňĆux, but correlation data are not shown in Table2 or in the ïňĄgure. Yes, indeed. We removed that sentence. Correlation coefficients are given in Table 1 instead.

References cited: Migon, C., Morelli, J., Nicolas, E. and Copin-Montégut, G. (1991) Evaluation of total atmospheric deposition of Pb, Cd, Cu and Zn to the Ligurian Sea. The Science of the Total Environment 105, 135-148.

Migon, C., Sandroni, V., Marty, J.C., Gasser, B. and Miquel, J.C. (2002) Transfer of atmospheric matter through the euphotic layer in the northwestern Mediterranean: seasonal pattern and driving forces. Deep-Sea Research II 49, 11, 2125-2142.

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Stokes, G.G. (1901) Mathematical and Physical papers, Vol. III. Cambridge University Press, Cambridge, 413 pp.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/7/C2268/2010/bgd-7-C2268-2010-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 7, 2549, 2010.

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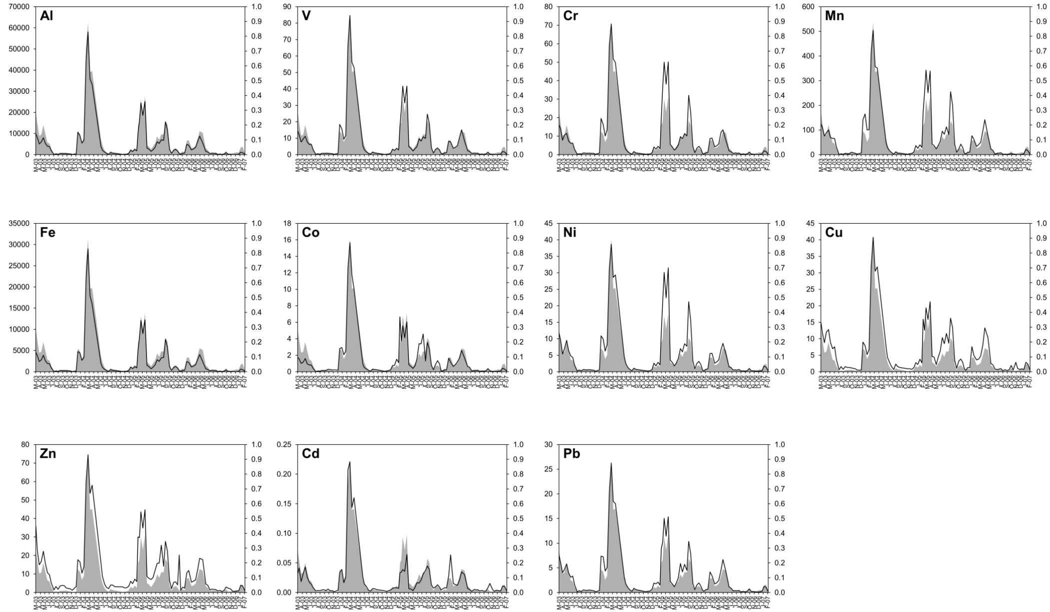

Fig. 1.

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